International Journal of Chemical &
Petrochemical Technology (IJCPT)
ISSN(P): 2277-4807; ISSN(E): 2319-4464
Vol. 4, Issue 1, Feb 2014, 1-18

TRANS STELLAR
• Journal Publications • Research Consultancy

PRODUCTION OF BIO-ETHANOL FROM AQUATIC WEEDS

ANUDEEP NAIDU MARIPI, JAYA BHARAT REDDY MARELLA & SAIRAM MADIREDDY

B. Tech Student, R. V. R & J. C College, Chandramoulipuram, Guntur, Andhra Pradesh, India

ABSTRACT

The world may not support society's current habits forever. We need new sources of energy, less co_2 emissions and more sustainable lifestyles. To put it on other way the world needs double the present supply of energy while cutting co_2 emissions to larger extent. To achieve more energy requirement with less co2 we need to conserve and diversify our energy sources sustainably. Bio fuels will and should become a vital part of the future energy mix. Sustainability should be the central idea to everything we do. Though in most parts of the world bio fuels is produced from corn and sugarcane, they compete with food sources. In a developing country like India food crisis is equal to energy crisis. Though corn and sugar cane yields high ethanol we cannot compromise on food security. Thus we need to look for other alternative raw-materials for producing bio fuels other than corn and sugarcanes. So I chose "weeds" a raw material which abundantly grown on waste waters and has some starch content in it. Weeds such as Duckweed can be the most promising plant for the twenty-first century because they are easier to harvest than algae or other aquatic plants. They provide food for wildlife, especially waterfowl due to high protein content in fact produces more protein per square meter than soybeans. Also there are 3% to 72% of starch content is present in the weeds which will used to convert into sugars and then to alcohol through fermentation. In this paper on type of weed which is called duckweed is selected and collected from local waste water bodies and used as raw material. This selection has a cutting edge upon food vs. fuel debate as weeds are abundantly available for free of cost. This weedy raw material is undergone various unit operations and process and then finally fermented to give out ethanol. This ethanol can be distilled and used as blend in petrol and a relatively clean burning biofuel can be obtained.

KEYWORDS: Aquaponics, Greenest Feedstock, Duckweed

INTRODUCTION

A Light upon Weeds

- A natural way of waste water treatment method.
- The plant feeds on nitrogen and phosphate organic pollutants, and in turn removes wastes from water.
- The world's "greenest" feedstock. Fast growing, high in protein and dietary minerals, and easily harvested, the plant is cultivated as a feed supplement for chicken, livestock, and farmed fish, especially in developing countries.
- An inexpensive, earth-friendly source of the bio fuel ethanol. Unlike corn, duckweed requires minimal human-made energy to grow and it doesn't deplete the world's food supply. A cleaner fuel.
- While weeds such as duckweed-produced ethanol, like other plant-based fuels, releases some carbon dioxide into the atmosphere, the plant also absorbs CO2 as it grows.
- Duckweed (lemnaceae, water lentils) family is the smallest flowering plants.
- They fastest growing plant, capable of doubling its weight in 24 hours.
- Duckweed grows well in still water, with a supply of mineral nutrients such as nitrogen and phosphorous solution

or organic nutrient such as compost tea, or the fish effluent from aquaponics.

- Duckweed is easier to harvest than algae or other aquatic plants.
- Duckweed can be used to feed fish, poultry and cattle.
- Duckweed provides food for wildlife, especially waterfowl due to high protein content. Also produces more protein per square meter than soybeans. This protein has higher concentrations of the essential amino acids, lysine and methionine.

BIO-ETHANOL

Bio-ethanol is usually obtained from the conversion of starch based feedstock. Agricultural feed stocks are considered renewable because they get energy from the using photosynthesis provided that all minerals required for growth (such as nitrogen and phosphorous) are returned to land.

Sugarcane Based Ethanol: sugarcane ethanol is the first most common type of ethanol which is produced from sugarcane as a biomass through industrial fermentation, chemical processing and distillation. Corn is the second major source of bio-ethanol.

The production of bio-ethanol can reduce dependency of many countries on oil producing countries. That is the reason why many countries developing corn or sugarcane fields and establishing ethanol production industries.

Current Demand for Ethanol

The demand for ethanol will continue to grow because of the fact that oil prices continue to increase and the energy sectors of today's economy continue to struggle that's the thought being shared by ethanol industry experts in a recent article published over on renewable energy world.

Table 1

Alcohol Production (In Million Liters)						
Alcohol Year	**Molasses Prod.**	**Production of Alcohol**	**Industrial Use**	**Potable Use**	**Other Uses**	**Surplus Availability**
1998-99	7.00	1411.8	534.4	5840	55.2	238.2
1999-00	8.02	1654.0	518.9	622.7	576	455.8
2000-01	8.33	1685.9	529.3	635.1	588	462.7
2001-02	8.77	1775.2	5398	647.8	59.9	527.7
2002-03	9.23	1869.7	550.5	660.7	61.0	597.5
2003-04	9.73	1969.2	578.0	693.7	70.0	627.5
2004-05	10.24	2074.5	606.9	728.3	73.5	665.8
2005-06	10.79	2187.0	619.0	746.5	77.2	742.3
2006-07	11.36	2300.4	631.4	765.2	81.0	822.8

In Brazil 20-24 per cent of ethanol is blended in gasoline. In the US, 10 per cent of ethanol, produced mainly from maize, is blended with gasoline.

There has been a steady increase in the production of alcohol in India, with the estimated production rising from 887.2 million liters in 1992-93 to nearly 1,654 million liters in 1999-2000. Surplus alcohol leads to depressed prices for both alcohol and molasses.

According to the task force, the projected alcohol production in the country will increase from 1869.7 million liters in 2002-03 to 2,300.4 million liters in 2006-07. Thus the surplus alcohol available in the country is expected to go up

from 527.7 million liters in 2002-03 to 822.8 million liters in 2006-07.

Utilization of molasses for the production of ethanol in India will not only provide value-addition to the byproduct, it can also ensure better price stability and price realization of molasses for the sugar mills. This will improve the viability of the sugar mills, which will in turn benefit cane growers.

With gasoline demand expected to increase from 7.9 million tons in 2001-02 to 11.6 million tons in 2006-07, the requirement of ethanol at 5 per cent blending is expected to rise from 465 million liters to 682 million liters.

Various Processes Available for Ethanol Production

There are several methods available and being developed for production of ethanol depending on the raw material and intermittent additives use there as follows:

- Manufacture of ethanol from sugarcane juice fermentation.
- Direct ethylene hydration process.
- By etherification hydrolysis.
- By enzyme hydrolysis starch based corn.
- Fermentation of cellulosic materials like wood, switch grass etc.

Starch based raw materials like sugarcane and corn are ideal for bio-ethanol production. Starch has to be converted to sugars and it in turn to ethanol. On the other hand conversion of cellulosic biomass to ethanol is less productive and more expensive than the conversion of sugarcane to ethanol.

Direct Ethylene Hydration Process

Direct ethylene hydration process is a catalytic gaseous reduction where approximately about 5 to 6 kgs of phosphoric acid is used.

Ethylene + water →ethyl alcohol (catalyst- H3po4)

The conversion in this process is about 4-25%.

Esterification Hydrolysis Process

Ester + water +acid→ ethanol

A reversible reaction between alcohol and carboxylic acid cause loss of water ad formation of ester.

The most plant matter consists of three key polymers cellulose, hemi-cellulose and lignin. These polymers are assembled into a complex, interconnected matrix within plant cell walls. Cellulose and hemi-celluloses are carbohydrates that can be broken down into fermentable sugars. The cellulosic and hemi-cellulosic portion of plant biomass is processed separately because they have different structures and sugar content.

Cellulose consists of long chains of glucose molecules arranged into a solid, 3D, crystalline structure. Hemi-cellulose is a branched polymer composed primarily of xylose molecules and some other sugars. Lignin is a rigid aromatic polymer is not a carbohydrate and cannot be converted into ethanol.

Technology that Use Bio-Ethanol

Ethanol based engines: presently bio-ethanol is most commonly used to power automobiles though it may be used

to power other vehicles such as farm tractors and airplanes. Ethanol consumption in an engine is approximately 51% higher than of gasoline since the energy per unit volume is 34% lower than for gasoline. However the higher compression ratios in an ethanol only engine allow for increase power output and better fuel economy than could be obtained with lower compression ratio. Most new cars are designed in U.S, Europe and Brazil to run on a blend of gasoline and ethanol. "Gasohol" is a mixture of 90%unleaded gasoline and 10% denatured ethanol. Ethanol's higher octane rating allows an increase of an engines compression ratio for increased thermal efficiency. High ethanol blends present a problem to achieve enough vapor pressure to for the fuel to evaporate and spark the ignition during cold weather in cold countries. When vapor pressure is below 45 kpa starting a cold engine becomes difficult.

The Bio-Ethanol Petro Mixture Based Automobile Engines Might be Useful in India also to Reduce the Dependency on Oil Rich Countries and Develop Renewable Source for Fuel

In many countries cars are mandated to run on mixtures of ethanol-gasoline. Brazil requires cars be suitable for 25% ethanol blend and has required various mixtures between 22-25% ethanol. The United States allows up to 10% blend. Beginning with the model year 1999 an increasing number of vehicles in the world are manufactured with engines which can run on any fuel from 0% up to 100% ethanol without modification.

Environmental Impact

Compared with conventional unleaded gasoline ethanol is a particulate free burning fuels source and causes less air pollution ethanol is bio degradable Bio-ethanol is considered to be better for the environment than gasoline. Ethanol-fueled vehicles produce lower carbon dioxide and monoxide emissions, and the same or lower levels of hydrocarbons and oxides of nitrogen emissions.

- There are basically two sources of Bio-Ethanol:
- Starch from corn, sugarcane etc.
- Cellulose from leaves, wood etc.

Safety and Health Considerations

Fuel ethanol should be handled in the manner as gasoline. Personal exposure should be minimized. Like gasoline, fuel ethanol is flammable, poisonous, and may contain additives that can be harmful even with casual contact. Fuel ethanol is poisonous and should not be swallowed. Exposure to fuel ethanol can occur by inhalation (breathing in its vapor), absorption (getting it on the skin or in the eyes), or ingestion (swallowing it).

PROCESS FLOW SHEET

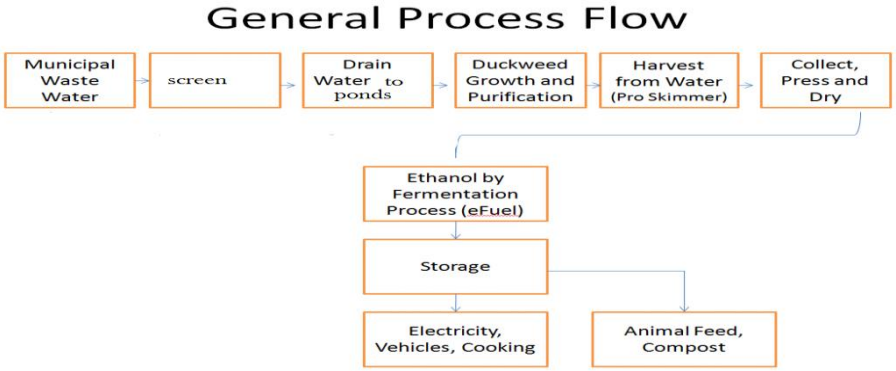

Figure 1

UNIT OPERATIONS

- Crushing
- Acid Hydrolysis
- Yeast Fermentation
- Distillation
- Dehydration

CRUSHING

This operation can be done to make the bagasse fiber into small pieces or a fine powder.

ACID HYDROLYSIS

- Hydrolysis is performed by attacking the cellulose with an acid.
- Dilute acid may be used under high heat and high pressure, or more concentrated acid can be used at lower temperatures and atmospheric pressure.
- A de crystallized cellulosic mixture of acid and sugars reacts in the presence of water to complete individual sugar molecules (hydrolysis).
- The product from this hydrolysis is then neutralized and yeast fermentation is used to produce ethanol.
- The purpose acid hydrolysis was to break-up lignin and make cellulose available for yeast fermentation.

Yeast Fermentation

The yeast saccharamyces cerevisiae, strain 765, was obtained from the American type culture collection. This strain is known to produce ethanol from cellulosic material. The role this yeast strained producing ethanol without saccharification.

$(C_6H_5O_{10})_{-n}+nH_2O \rightarrow nC_6H_{12}O_6$

$C_6H_{12}O_6 \text{-----} \rightarrow 2C_2H_5OH+2H_2O$

The product coming from the acid hydrolysis is sent to the yeast fermentation process. In this cellulose is converted into glucose.

Distillation

The product coming from the fermentation is sent into distillation to remove water present in the mixture in this process the water cannot be removed completely, so for the complete removal this is sent to the dehydration process.

Dehydration

The output from distillation contains about 95-96% ethanol. It cannot further concentrate using distillation because it forms an azeotrope at 95%. It is passed through a molecular sieve to physically separate the remaining water from the ethanol based on the different sizes of the molecules.

EXPERIMENTAL PROCEDURE IN LAB SCALE

Weed Preparation

- Initially take certain amount of weedy material and dried under sunlight. (moderate climatic conditions)
- It takes one-two days (depending upon the climatic conditions) to remove the moisture present in the weeds.
- Then weedy material is splitted into small pieces and from that take 60g of dry weedy powder.

Acid Hydrolysis

- Prepare 0.5N hydrochloric acid solution.
- Now 60g of dry weedy material is added to this 0.5N hydrochloric acid solution.
- This is kept for one day.
- After completion, filter the mixture and separate the liquid from the solid.
- Liquid (glucose + water) is sent to fermentation process.

Test for Glucose

There are two possible tests for glucose Benedict's reagent Fehling's solution

Benedict's Reagent

- Benedict's reagent is a solution of copper sulphate, sodium hydroxide and tartaric acid
- Aqueous glucose is mixed with Benedict's reagent and heated
- The reaction reduces the blue copper (+2) ion to form a orange/brick red precipitate of copper (+1) oxide.

OBSERVATION: Orange precipitated solution is observed

Fehling's Solution

- Fehling's solution comprises of two solutions A and B
- Fehling solution A is a solution of copper (+2) sulphate pent hydrate in water
- Fehling solution B is a solution of Rochelle salt (potassium sodium tartarate tetrahydrate) and sodium hydroxide in water
- The reaction reduces the blue copper (+2) ion to form a brick red precipitate of copper (+1) oxide

OBSERVATION: Brick red predicated solution is observed

Preparation of Inoculums (Medium)

Why medium is required??

- The yeast that was bought was initially in inactive state.
- Medium is required to bring yeast into an active state from inactive state.
- There are different types of medium. some of them are starter culture, LB broth

Preparation of LB Broth

- A clean conical flask which was autoclaved is taken
- 2g of peptone, 1g of sodium chloride, 0.6g of yeast extract are added in 200 ml distilled water.
- The conical flask is swirled slowly in order to ensure that solution is free from clots.
- Then the flask is closed (cotton plugged) and kept in autoclave reactor for 20 min at temperature of 120 C and pressure of 1.4-1.5 kgf/cm2.(for sterilization)
- After 20 min we found that the dark yellow color of the solution was changed into light yellow color solution which indicates that the autoclave quality assurance had been successfully achieved.
- This solution is opened and 1 g of yeast is added to it under Laminar air flow apparatus (LAF) in order to avoid contamination.
- The flask is kept for 1 day so that, yeast had been grown up to its microbe level.
- After 1 day growth and budding of yeast is observed under electron microscope.
- The resulting solution is often known as inoculums/medium which is used for fermentation process.

Fermentation Process

- Liquid coming from the acid hydrolysis was sent into a flask which was stoppered.
- To this, 6 ml inoculums is added and kept on a shaker at 25 C and 150 rpm.
- This process is carried out for three days.
- By the action of yeast glucose is converted to ethanol and carbon dioxide.
- This liquid solution is sent to distillation process.

Distillation Process

- The liquid from fermentation process is taken into the simple distillation column.
- At 80 C, we collected the distillate about 11ml.
- We observed that the distillate consists of strong ethanol odor.

MATERIAL BALANCE

Mathematically the mass balance for a system without a chemical reaction is as follows

$$\text{Input} = \text{Output} + \text{Accumulation}$$

A mass balance (also called a material balance) is an application of conservation of mass to the analysis of physical systems. By accounting for material entering and leaving a system, mass flows can be identified which might have been unknown, or difficult to measure without this technique

Material Balance for Crusher: The crusher is used to split the weedy material into small pieces.

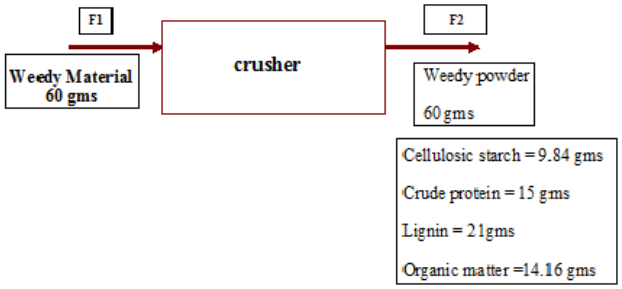

Figure 2

Over all mass balance is

Input = out put

Material Balance for Acid Hydrolysis

The product that is coming from the crusher is fed to acid hydrolysis as a feed.

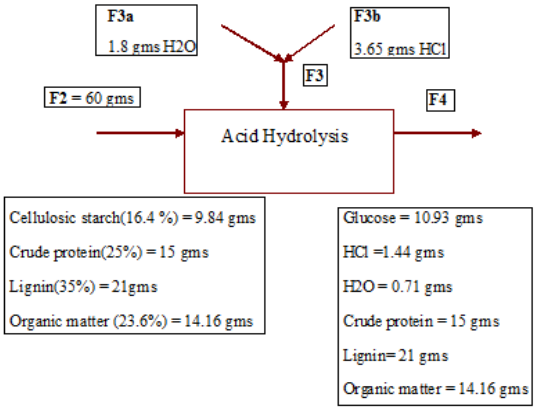

Figure 3

F3a = ((Normality of H2O)*(Gram equivalent weight of H2O)*(volume of water added in ml))/1000

= (1*18*100)/1000

= 1.8 gms of H2O

F3b = ((Normality of HCl)*(GEW of HCl)*(volume of HCl added in ml))/1000

= (0.5*36.5*200)/1000

= 3.65 gms of HCl

Reaction involved:

$(C_6H_{10}O_5)_n + nH_2O$ ----->n $C_6H_{12}O_6$

Cellulosic starch + water -----> glucose

According to stoichiometry,

162 gms of cellulosic starch requires 18 gms of water

9.84 gms of cellulosic starch requires = (9.84*18)/(162)

= 1.09 gms of water

Similarly,

162 gms of cellulosic starch produces 180 gms of glucose

9.84 gms of cellulosic starch produces = (9.84*180)/(162)

=10.93 gms of glucose

36.5 gms of HCl is required to produce 180 gms of glucose gms of HCl is required to produce10.93gms of glucose = (10.93*36.5)/(180)

= 2.21 gms of HCl is required.

Quantity of H2O remained = 1.80 – 1.09 = 0.71 gms

Quantity of HCl remained = 3.65 – 2.21 = 1.44 gms

Material Balance for Filter

The output from the acid hydrolysis tank is send to the filtration process. This consists of two phases that are solid and liquid. The filter is used to separate the solid and liquid phases. Here our useful product was bottom liquid and top product was drawn out.

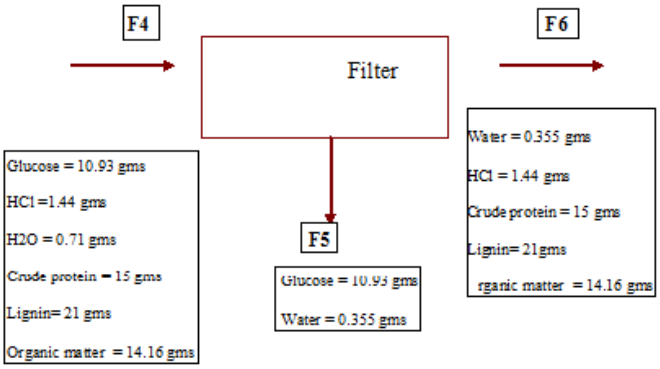

Figure 4

Assume moist solid contain 50% water

Water = (0.71 – 0.71*0.5) = 0.355 gms of water

Material Balance for Fermentor

The bottom product from the filter is send as input to the fermentor. Here the reaction is conversion of glucose to ethanol and carbon dioxide.

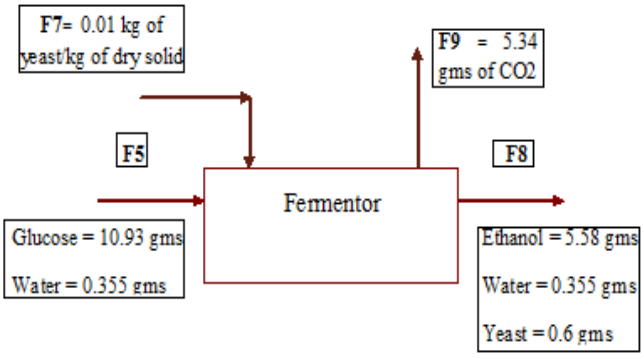

Figure 5

1 kg dry solid requires 0.01 kgs of yeast

1000 gms dry solid requires 10 gms of yeast

60 gms of dry solid requires.....?

= (60*10)/1000

= 0.6 gms of yeast.

Reaction Involved

$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2CO_2$

According to stoichiometry,

180gms of glucose produces 2(46)gms of ethanol

10.93 gms of glucose produces…….?

= (10.93*2*46)/(180) = 5.58 gms of ethanol

Similarly,

180 gms of glucose produces 2*44*gms of CO_2

10.93 gms of glucose produces……? = (10.93*2*44)/180 = 5.34 gms of CO2

ENERGY BALANCE

Energy balance consists of calculating the enthalpies of all streams and leaving a unit operations the heat generated and observed for a chemical reaction has also be taken into account. Since experimental data of heat capacities for certain polymeric compounds and carbohydrates is lacking, kopp's rule comes into an existence.

Kopp's Rule

The rule that the heat capacity of 1 mole of a solid substance is approximately equal to the sum over the elements forming the substance of the heat capacity of a gram atom of the element times the number of atoms of the element in a molecule of the substance.

Known Specific Heat Capacities

Specific heat capacity of carbon(C) = 0.709J/gK

Specific heat capacity of hydrogen (H2) = 14.304J/gK

Specific heat capacity of oxygen (O2) = 0.918J/gK

Specific heat capacity of nitrogen (N2) = 1.04J/gK

Specific heat capacity of phosphorous (P) = 0.769J/gK

Specific heat capacity of HCl = 4.03J/gK

Specific heat capacity of H2O = 4.1813J/gK

Specific heat capacity of CO2 = 1.627J/gK

Now we have to calculate specific heat capacities of duckweed, cellulosic starch, crude protein, lignin, organic matter, glucose, ethanol using kopp's rule.

Duckweed

Molecular formula: $C_{102}H_{159}O_{60}N_9P$

Specific heat capacity of duckweed = 102(Cp of C)+79(Cp of H2)+(Cp of H)+30(Cp of O2)+4(Cp of N2)+(Cp of N)+(Cp of P)

= 102(0.709)+79(14.304)+0+30(0.918)+4(1.04)+0+0.769 = 1234.803 J/gK

Cellulosic Starch

Molecular Formula: $C_6H_{10}O_5$

Specific heat capacity = 6(Cp of C)+5(Cp of H2)+2(Cp of O2)+(Cp of O)

= 6(0.709)+5(14.304)+2(0.918)+0

= 77.61 J/gK

Crude Protein

Molecular Formula: $C_6H_{14}O_2N_2$

Specific heat capacity = 6(Cp of C)+7(Cp of H2)+(Cp of O2)+(Cp of N2)

= 6(0.709)+7(14.304)+(0.918)+(1.04)

= 106.34 J/Gk

Lignin

Molecular formula: $C_{10}H_{12}O_3$

Specific heat capacity = 10(Cp of C)+6(Cp of H2)+(Cp of O2)+(Cp of O)

= 10(0.709)+6(14.304)+0.918+0

= 93.832 J/gK

Organic Matter

Specific heat capacity of organic matter

= (Cp of duckweed) –((Cp of cellulosic starch)+(Cp of lignin)+(Cp of crude protein))

= (1234.803)-(77.61 +93.832 +106.34)

= 957.021 J/gK

Glucose

Molecular formula: $C_6H_{12}O_6$

Specific heat capacity = 6(Cp of C)+6(Cp of H2)+3(Cp of O2)

= 6(0.709)+6(14.304)+3(0.918) = 92.832 J/gK

Ethanol

Molecular formula: C2H5OH

Specific heat capacity = 2(Cp of C)+3(Cp of H2)+(Cp of O)

= 2(0.709)+3(14.304)+0

= 44.330 J/gK

Energy Balance for Crusher

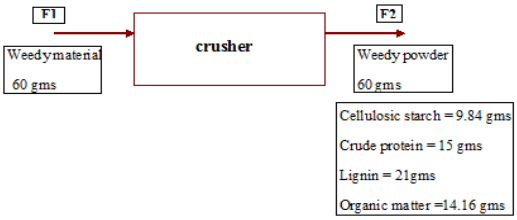

Figure 6

Reference temperature = 0^0C = 273 K

Inlet temperature = 30^0C = (30+273) = 303 K

Mass of weed material = 60 gms

Enthalpy in, $H_1 = \sum m_i c_{pi} (T_i - T_{ref})$

= 60*1234.803 *(303-273)

= $2.22*10^3$ kJ

Enthalpy out, $H_2 = \sum m_0 c_{p0} (T_0 - T_{ref})$

= [(9.84*77.61) + (15*106.34)+

(21*93.832) +(14.16*957.021)](303—273)

= $5.36*10^2$ kJ

Thermal energy required = $H_1 - H_2$

= $2.22*10^3 - 5.36*10^2$

= 1.68 kJ

Energy Balance for Acid Hydrolysis

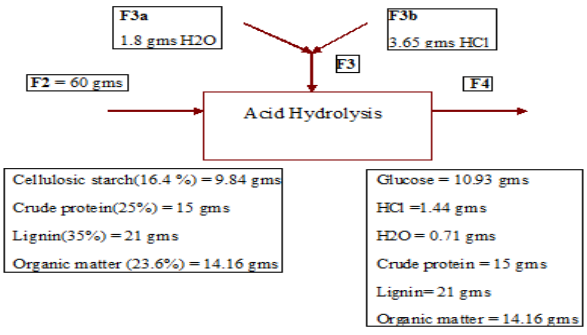

Figure 7

Enthalpy in, H2 = $\sum m_i c_{pi} (T_i - T_{ref})$

= [(9.84*77.610) + (15*106.34)+

(21*93.832)+(14.16*957.021)+(1.8*4.1813)+(3.65*4.03)](303-273)

= $5.37*10^2$ kJ

Enthalpy out, H4 = $\sum m_0 c_{p0} (T_0 - T_{ref})$

= [(10.93*92.832)+ (0.71*4.181)+(1.44*4.03)+ (15*106.34)+

(21*93.832)+(14.16*957.021)](303 - 273)

= $5.44*10^2$ kJ

Thermal energy required = $H_4 - H_2$

=$5.44*10^2 - 5.37*10^2$

= 7.0 J

Energy Balance for Fermentor

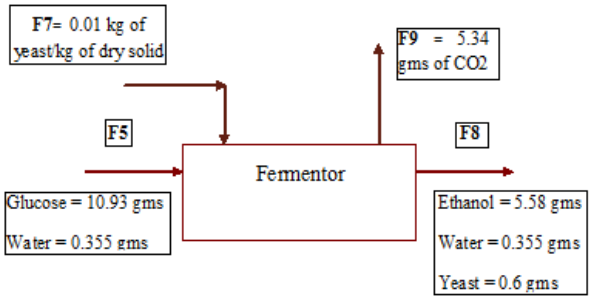

Figure 8

Enthalpy in, H5 = $\sum m_i c_{pi} (T_i - T_{ref})$

= [(10.93*92.832)+(0.355*4.181)](303-273)

= 30.4 kJ

Enthalpy out, H9 = $\sum m_0 c_{p0} (T_0 - T_{ref})$

= 5.34*1.627*(303-273)

= 0.26 kJ

Enthalpy out, H8 = $\sum m_0 c_{p0} (T_0 - T_{ref})$

= [(5.58*44.33)+(0.355*4.181)](303-273)

= 7.465 kJ

Thermal energy required = H5-(H8+H9)

= 30.4 – (7.465 + 0.26)

= 22.675 kJ

ANALYSIS OF ETHANOL SAMPLE

There are two methods of analyzing ethanol sample

- Gas chromatography
- Titration method

TITRATION METHOD

RESULTS AND CALCULATIONS

Blank Titration

Volume of hypo run down = 23.8 ml

Molarity of hypo = 0.03 moles/litre

Number of moles of hypo in the run down volume = (23.8*0.03)/1000

$= 7.14*10^{-4}$ moles

According to stoichiometry,

1 mole of $S_2O_3^{-2}$ is equivalent to 0.25 moles of C2H5OH

No of moles of C_2H_5OH = (number of moles of hypo run down*0.25)

$= 7.14*10^{-4}*0.25$

$= 1.85*10^{-4}$ moles

In grams

No. of grams of C2H5OH = (number of moles of C2H5OH*molecular weight of ethanol)

$= 1.85*10^{-4}*46$

$= 8.51*10^{-3}$ gms (initial)

Sample Titration

Volume of sample added = 1 ml

Volume of hypo run down = 23.6 ml

Molarity of hypo = 0.03 moles/litre

Number of moles of hypo in the run down volume = (23.6*0.03)/1000

$= 7.09*10^{-4}$ moles

According to stoichiometry,

1 mole of $S2O3^{-2}$ is equivalent to 0.25 moles of C2H5OH

No of moles of C2H5OH = (number of moles of hypo run down*0.25)

$= 7.09*10^{-4}*0.25$

$= 1.77*10^{-4}$ moles

In grams

No. of grams of C2H5OH = (number of moles of C2H5OH*molecular weight of ethanol)

$= 1.77*10^{-4}*46$

$= 8.15*10^{-3}$ gms (final)

Percentage Yield of Ethanol

Percentage yield of ethanol = ((initial – final)/initial)*100

$= ((8.51*10^{-3} - 8.15*10^{-3})/(8.51*10^{-3}))*100$

= ((8.51-8.15)/8.51)*100

= (0.36/8.51)*100

= 0.042303*100

= 4.2303 %

CONCLUSIONS

A better alternate solution for food vs. fuel problem is production bio fuel from weeds. Thus this paper is done to find the possibilities of using the typically grown weed called duckweed in producing bio-ethanol. As exemplified by this project, aquatic weed illustrated its ability to grow rapidly. Weeds also helped to remediate waste water, abundant in toxic nutrients, making it ideal to deploy on global scale. Thus weeds offer a presently optimal solution in efficiently soothing energy as well as food crisis issues. However, the result in this paper i.e. 4.2% yield coefficient is not enough with exponentially rising demands for energy and clean water.

Hence my future research in this filed include finding the best location for duckweed growth in terms of surface area and climate and finding techno-economically feasible and more efficient systems for this process. Larger scale experiments should be conducted to prove the feasibility of ethanol mass production as well as to test weed's ability to absorb phosphates and other toxic chemicals affecting water sources. While the current economic pressures have put constraints on funding new scientific endeavors, a new market should expand for weed-produced ethanol based upon its efficiency in process and abundance in water sources. Thus this paper is now being substantiated as a possible source for ethanol production and is increasingly more adept at handling the energy and clean water crisis.

ACKNOWLEDGEMENTS

First and foremost I offer my sincerest gratitude to our institution R.V.R. & J.C. College of Engineering for providing me with an opportunity to fulfill my cherished dream to have an exposure as an undergraduate and for building a strong foundation of basic knowledge in the technical field of Chemical Engineering.

I feel very happy to record my sincere thanks to our principal Dr. A. Sudhakar for providing a stimulating environment at our college campus.

I take this opportunity to express my profound gratitude and deep regards to my guide Dr. M. Venkateswara Rao, Professor and Head, Department of Chemical Engineering for his exemplary guidance, monitoring and constant encouragement throughout the course of this project. The blessings, help and guidance given by him time to time shall carry me a long way in the journey of life and attribute in my future endeavors.

I am greatly indebted to Dr.P.Krishna Kanth, Professor and Head, Department of Biotechnology for his help, encouragement and company on the numerous tips. His willingness to help students provided enormous benefit to us. It was great working with him and in many ways I have learnt much from and because of him.

I wish to extend my sincere gratitude to our advisor Dr.K.Sobha, Associate professor, Department of Biotechnology for her tireless efforts, guidance, and timely advice throughout my project work.

I would not have accomplished the work I did without the support and resources of the above-mentioned individuals

M. ANUDEEP NAIDU, M. JAYA BHARAT REDDY, M. SAIRAM

REFERENCES

1. Arja Miettinen Oinonen, Pirkko Suominen. Enhanced Production of Trichoderma reesei Endoglucanases and Use of the New Cellulase Preparations in Producing the Stonewashed Effect on Denim Fabric. Applied and Environmental Microbiology. Aug. 3956-3964 (2002).
2. A Caputi Jr, Ueda M, Brown T. Am. J. Enol. Vitic. 19,160-165 (1968).
3. Bahkali A H. Influence of various carbohydrates on xylanase production by Verticillium tricopus. Bioresour Technol. 53(3), 265-268 (1996).
4. Belkis Çaylak, Fazilet Vardar Sukan. Comparison of Different Production Processes for Bioethanol. Turk J Chem. 22, 351 – 359 (1998).
5. Bin Yang, Yanpin Lu. Perspective The promise of cellulosic ethanol production in China. J Chem Technol Biotechnol. 82, 6–10 (2007).
6. Das H, Singh S K. Useful byproducts from cellulosic wastes of agriculture and food industry-a critical appraisal. Crit Rev Food Sci Nutr. 44(2), 77-89 (2004).
7. Esterbauer H, Steiner W, Labudova I, Hermann A, Hayn M. Production of Trichoderma cellulase in laboratory and pilot scale. Bioresour Technol. 36, 51–65 (1991).
8. Gadgil N J, Daginawala H.F, Chakrabarti T, Khanna P. Enhanced cellulase production by a mutant of Trichoderma reesei. Enzyme and Microbial Technology, 17(10), 942-946 (1995).
9. Hayward T K, Hamilton J, Tholudur A, Mc Millan J D. Improvements in titre, productivity, and yield using solka-floc for cellulase production. Appl. Biochem. Biotechnol. 84/86(1-9), 859-874 (2000).
10. Joeh T. Steam explosion pretreatment of cotton gin waste for fuel ethanol production. [Blacksburg, Va: University Libraries, Virginia Polytechnic Institute and State University] MSc Thesis. http://scholar.lib.vt.edu/theses/available/etd-011499-120138. (2000).
11. Kirk O, Borchert T V, Fuglsang C C. Industrial enzyme applications. Curr Opin Bio technol. 13, 345–51 (2002).
12. Kitchaiya P, Intanakul P, Krairiksh M. Enhancement of enzymatic hydrolysis of lignocellulosic wastes by microwave pretreatment under atmospheric pressure. Journal of Wood Chemistry and Technology, 23(2), 217-225 (2003).
13. Klapatch T R, Hogsett D A L, Baskaran S, Pal S, Lynd L R. Organism development and characterization for

ethanol production using thermophilic bacteria. Appl. Biochem. Biotechnol. 45/46, 209-223 (1994).

14. Lee R Lynd, Paul J Weimer, Willem H, Van Zyl, Isak S Pretorius. Microbial Cellulose Utilization: Fundamentals and Biotechnology Microbiology and Molecular Biology Reviews, 506–577 (2002).
15. Mach R L, Zeilinger S. Regulation of gene expression in industrial fungi: Trichoderma. Appl. Microbiol. Biotechnol. 60, 515-522 (2003).
16. Magnelli P, Forchiassin F. Regulation of the cellulase complex production by Saccobolus saccoboloides: Induction and repression by carbohydrates. Mycologia, 91(2), 359-364 (1999).
17. Mandels M, Reese E T. Induction of cellulase in Trichoderma viridae as influenced by carbon source and metals. J. Bacteriol. 73, 269-278 (1957).